ADMINISTRATIVE INFORMATION

1. **Project Name:** Materials for Industrial Heat Recovery Systems

2. **Lead Organization:** Weyerhaeuser Company
P. O. Box 9777 - WTC 2H22
Federal Way, WA 98063-9777

3. **Principal Investigator:** J. Peter Gorog, Weyerhaeuser Company
253-924-6514
peter.gorog@weyerhaeuser.com

4. **Project Partners:** Oak Ridge National Laboratory, James R. Keiser
865-574-4453, keiserjr@ornl.gov
Institute of Paper Science and Technology at Georgia Tech, Preet Singh
404-894-5700, preet.singh@ipst.edu
University of Kentucky, Subodh K. Das
859-514-4989, skdas@engr.uky.edu
Pulp and Paper Research Institute of Canada, Douglas L. Singbeil
253-222-3254, dsingbeil@paprican.ca

5. **Date Project Initiated:** To Be Determined, 2004

6. **Expected Completion Date:** To Be Determined, 2007

PROJECT RATIONALE AND STRATEGY

7. **Project Objective:** The project will address materials improvements for enhanced heat recovery, reliability and competitiveness in two industries: Aluminum and Forest Products. The Aluminum and Forest Products Industry Technology Roadmaps specifically identify the need for fuel efficience and cost effectiveness in melters and recovery boilers, respectively. By determining the cause of tube degradation and identifying more reliable materials, the improved technology identified in this project will result in improved energy efficiency in two very energy intensive industrial systems.

8. **Technical Barrier(s) Being Addressed:** The technical barriers involve the need to determine degradation mechanisms for components of selected heat recovery systems and then to identify more suitable materials for those components. For the aluminum furnace recuperators, the tubes suffer thinning, cracking and warping. In the recovery boilers, some tubes that form the primary air port openings experience cracking and thinning in certain locations, some superheater tubes undergo thinning at the lower end and cracking and/or thinning near the top of the boiler, carbon steel wall tubes near the center of the furnace sometimes incur severe localized thinning while smelt spouts sometimes experience cracking and or thinning.

9. **Project Pathway:** This project will utilize materials improvements to achieve enhanced heat recovery, reliability and competitiveness in two industries: Aluminum and Forest Products. To achieve these goals, challenging materials problems in the area of strength and environmental degradation must be overcome. These difficult materials problems will receive an integrated

experimental, characterization, field evaluation, and modeling effort involving industry, research organizations, materials suppliers and component manufacturers.

10. **Critical Technical Metrics:** The cost savings from the introduction of alternate materials would occur primarily through energy savings and through improved efficiency for existing heat recovery systems, greater penetration of the potential market, improved reliability (reduced outages) of the heat recovery systems and, most significantly, through enhanced capacity. The cost savings for the Aluminum Industry would occur through 1) improved efficiency of existing recuperators, 2) reduction of energy lost due to frequent outages, and 3) greater penetration of the use of recuperators in the market. For the Forest Products Industry cost savings would be achieved through an overall 1.5% energy efficiency gain in new recovery boiler systems and a 20% increase in capacity in rebuilt boilers.

PROJECT PLANS AND PROGRESS

11. **Past Accomplishments:** Not applicable, project initiated in FY04 except for Task 2 which is a continuation of previous project on cracking and corrosion of recover boiler primary air port composite tubes. For the air port project, a significant amount has been accomplished including a determination of the association between severe temperature fluctuations and the likelihood of cracking, a demonstration that certain alloys are more resistant to cracking and a relationship between certain operating parameters and the temperature fluctuations. These accomplishments have been described in a number of recent publications.

12. **Future Plans:**

    1. Install equipment to monitor temperature and stresses in recuperator. In order to determine the degradation mechanism, an understanding is needed of the conditions to which the recuperator tubes are exposed. 08/01/2004
    2. Make residual stress measurements and finite element modeling on cracked primary air port opening tubes. Information on residual stresses in the composite tube cladding is needed in order to quantify the stresses that drive crack initiation and other information is needed to understand why cracks sometimes can advance into the carbon steel. 07/01/2004
    3. Initiate laboratory tests in mid-furnace environments identified during earlier studies and evaluate performance of alternate alloys, metal spray, weld overlay and co-extruded tubes. 06/30/2005
    4. Characterize the performance of superheater tubes. The corrosion and cracking behavior of superheater tubes in various boiler designs will be determined. 04/01/2005
    5. Prepare and submit final report. Planned Completion Date 05/31/2007

13. **Project Changes:**

    Some industrial members of the team have expressed an interest in having corrosion and cracking of smelt spout openings included in the topics that will be studied.

14. **Commercialization Potential, Plans, and Activities:**

    Technology commercialization will involve two phases. In the Research and Development Phase, the investigative team will focus on the generation and development of understanding of failure mechanisms and materials properties and performance requirements to overcome the deficiencies. This will be conducted in close collaboration between researchers and industrial representatives. In the Feasibility Phase materials models and alternate materials will be exposed in recuperator and

recovery boiler conditions, allowing companies to obtain first-hand information on the implementation of the technology and to directly participate in the commercialization of the technology. This will enhance rapid and well-understood technology and knowledge transfer to the industrial partners.

15. **Patents, Publications, Presentations:**

Patents: None to date.

Publications:
"Current Understanding of Cracking of Recovery Boiler Primary Air Port Composite Tubes" proceedings of the 2003 TAPPI Fall Technical Conference, October 27-29, 2003, Chicago, IL
"Current Understanding Of Cracking Of Recovery Boiler Primary Air Port Composite Tubes" proceedings of the 2004 TAPPI Paper Summit, May 3-5, 2004, Atlanta, GA
"Cracking and Corrosion of Composite Tubes in Black Liquor Recovery Boilers" published in proceedings of International Recovery Boiler Conference, May 12-14, 2004, Porvoo, Finland
"Causes And Solutions For Recovery Boiler Primary Air Port Composite Tube Cracking" proceedings of the 11th International Symposium on Corrosion in the Pulp and Paper Industry, June 8-11, 2004, Charleston, SC

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"Current Understanding of Cracking of Recovery Boiler Primary Air Port Composite Tubes" presented at the University of Toronto 2003 Annual Research Review Meeting, November 19-20, 2003, Toronto, Ontario
"Current Understanding of Recovery Boiler Primary Air Port Composite Tube Cracking" presented at the February 4, 2004, AF&PA Recovery Boiler Meeting, Atlanta, GA
"Current Understanding Of Cracking Of Recovery Boiler Primary Air Port Composite Tubes" presented at the 2004 TAPPI Paper Summit, May 3-5, 2004, Atlanta, GA
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